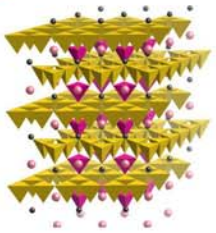
Cobalt: More Than Just Two Steps From Mn

J.F. Mitchell[a], J. C. Burley[a], H. Zheng[a], S. Rosenkranz[a], R. Osborn[a], A. Huq[b], J. Wu[c], C. Leighton[c], P. Stephens[d], L. Chapon[e], P.G. Radaelli[e]

[a] Materials Science Division, [b]Intense Pulsed Neutron Source,[c]Univ. Minnesota, [d]SUNY Stonybrook, [e]ISIS Facility, Rutherford Laboratory, UK

Known cobalt oxides — an opportunity to explore charge, spin, and orbital physics
New materials — a platform to enhance understanding of geometric frustration

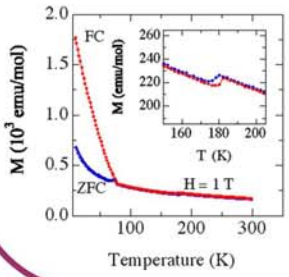
New Materials: Geometrically Frustrated Cobaltites



Motivation

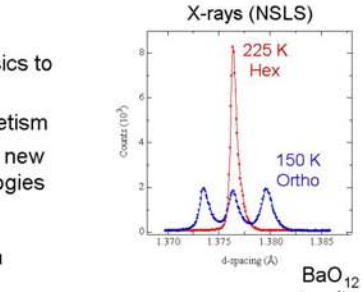
- Extension of oxide physics to tetrahedral systems
- Low-dimensional magnetism
- Geometric frustration in new structures and topologies

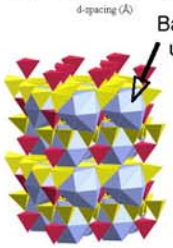
$YbBaCo_4O_7$: Kagomé layers linked by tetrahedra 75% Co^{2+} + 25% Co^{3+}; geometrically frustrated structure akin to pyrochlore with alternative stacking sequence for triangular layer

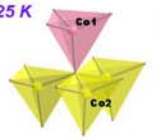


T~180 K: Structural transition? Possible Co^{2+}/Co^{3+} ordering?

T~80 K: magnetic transition—what is ground state?.

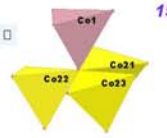




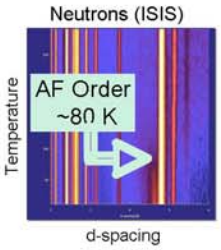


<d_{Co-O}>	
Co1	1.959 Å
Co2	1.918 Å

T_d Co^{3+} 1.79 Å



<d_{Co-O}>	
Co1	1.920 Å
Co21	1.949 Å
Co22	1.937 Å
Co23	1.925 Å



Hex ⟶ ortho phase transition driven by highly underbonded Ba site (BVS = 1.3 at 225 K !), ***not*** Co^{2+}/Co^{3+} charge order. Removes geometric frustration and allows long-range AFM state

Future Plans:

- Prepare series with several R^{3+}; xtal growth
- Study role of O content
- Comprehensive neutron diffraction
- Use chemistry to prevent phase transition, make it magnetically frustrated

Spin States and Phase Homogeneity in $La_{1-x}Sr_xCoO_3$

Motivation

Multiple spin states on Co^{3+} build on rich interplay of charge, spin, orbital order found in manganites

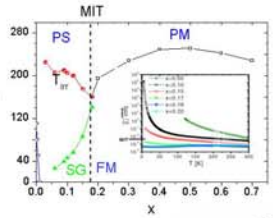
Issues:

- Controversy over existence of IS (S=1) state in Co^{3+}
- Will IS be Jahn-Teller (J-T) active?
- What is nature of insulator-to-metal transition

To address these issues, we grew first single phase crystals across transition at x=0.18

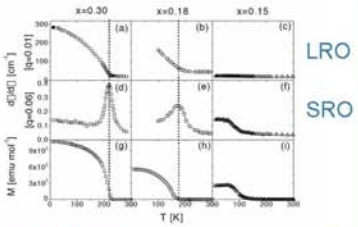
ω = 0.6 meV

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.



SANS:

- Short-range clusters for x < 0.18
- Long-range ordered FM for x > 0.18
- Percolative insulator-metal transition



AFM ⟷ FM

QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.

- Inelastic neutron scattering reveals *dynamic* FM and AFM correlations
- Suggests dynamic orbital order akin to A-type orbital ordered phase of $LaMnO_3$
- Indirect evidence of IS Co^{3+} with J-T mode

Future Plans:

- Crystal growth of x ≥ 0.3 to understand SRO-LRO crossover
- Diffuse scattering to explore incoherent Jahn-Teller distortion (MSD group)

D. Phelan, D. Louca, S. Rosenkranz, S.-H. Lee, Y. Quiu, P.J. Chupas, R. Osborn, H. Zheng, J.F. Mitchell, J.R.D. Copley, J.L. Sarrao and Y. Moritomo Phys. Rev. Lett. 96, 027201 (2005)

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